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Notice of and reasons for the Final Determination

The NSW Threatened Species Scientific Committee, established under the *Biodiversity Conservation Act 2016* (the Act), has made a Final Determination to list *Leucopogon fletcheri* Maiden & Betche subsp. *fletcheri* as a VULNERABLE SPECIES in Part 3 of Schedule 1 of the Act and, as a consequence, to omit reference to *Leucopogon fletcheri* Maiden & Betche subsp. *fletcheri* from Part 2 of Schedule 1 (Endangered species) of the Act. Listing of Vulnerable species is provided for by Part 4 of the Act.

Summary of Conservation Assessment

Leucopogon fletcheri Maiden & Betche subsp. *fletcheri* was found to be Vulnerable in accordance with the following provisions in the *Biodiversity Conservation Regulation 2017*: Clause 4.3(c)(d)(e i,iii). The main reasons for this species being eligible for listing in the Vulnerable category are (1) the taxon has a highly restricted geographic distribution with an extent of occurrence of 2,035 km^2 and an area of occupancy of 88 km^2; (2) the taxon occurs in eight threat-defined locations; and (3) it is estimated and inferred that continuing decline in the area, extent and quality of habitat, and the number of mature individuals is occurring due to the combined threats of the clearing, fragmentation, and degradation of habitat, and adverse fire regimes, particularly high frequency fire, more intense or severe fire, and changes in fire season.

The NSW Threatened Species Scientific Committee has found that:

1. *Leucopogon fletcheri* Maiden & Betche subsp. *fletcheri* (Ericaceae) is described as a “densely branched shrub to 1.8 m high; branchlets scabrous. Leaves oblong-linear, 3.7–8 mm long, 1.4–3.1 mm wide; apex acute, tip pungent to 1.0 mm long; base truncate; margins entire or minutely toothed; lamina thin, convex, striate-ribbed on lower surface; petiole to 0.3 mm. Flowers pendent, mostly solitary plus rudiment, but occasionally in 2 or 3 (particularly in the Springwood-Winmalee area), in spikes crowded at end of branches, white; recurved peduncles to 1.5 mm long; bracteoles 1.2–1.6 mm long. Sepals 3.4–4.6 mm long. Corolla tube 3.5–4.8 mm long, sparsely pubescent above middle; lobes erect at base, 2.4–3.8 mm long; ovary 1–1.9 mm long; style 5.4–7.9 mm long” (PlantNet 2023a).
2. *Leucopogon fletcheri* was first described by Maiden and Betche (1897) from material collected near Springwood by J. J. Fletcher. It was subsequently split into two subspecies by Powell and Robertson (1993), who considered the two taxa to be allopatric. *Leucopogon fletcheri* subsp. *fletcheri* has no known synonyms (CHAH 2023). PlantNet (2023b) distinguishes the nominate subspecies from *L. fletcheri* subsp. *brevisepalus* by having mostly solitary flowers, longer sepals at 3.4–4.6 mm, a longer corolla tube at 3.5–4.8 mm long, a larger ovary at 1–1.9 mm long, a longer style at 5.4–7.9 mm long, and larger fruit, which are obovoid, not ellipsoid.
3. *Leucopogon fletcheri* subsp. *fletcheri* is endemic to the Sydney Basin Bioregion (SEWPaC 2012). The taxon’s known distribution is bounded roughly by St Albans in the north, Springwood in the west, Kenthurst in the east, and Kentlyn in the south. The distribution of *L. fletcheri* subsp. *fletcheri* spans the traditional lands of the Eora, Tharawal, Dharug, Gundungurra, and Kuring-gai peoples (NNTT 2013;

AIATIS 2023). The population of *L. fletcheri* subsp. *fletcheri* is considered to consist of seven subpopulations.

4. The population size of *Leucopogon fletcheri* subsp. *fletcheri* is estimated to range from 47,669–50,012 mature individuals, based on extrapolated survey data from the seven subpopulations: St Albans (20–200 mature individuals); Maroota Ridge (229 mature individuals); Blaxlands Ridge (633–1,165 mature individuals); Lower Blue Mountains (45,943–46,674 mature individuals); Glenbrook (144 mature individuals); Upper Blue Gum Creek (200–600 mature individuals); and Kentlyn (500–1,000 mature individuals). Accurately estimating the number of mature individuals of *L. fletcheri* subsp. *fletcheri* is difficult, as surveys were conducted at different times, abundance estimates frequently lack demographic information, and several subpopulations have likely been burnt since the last surveys. Estimates of mature individuals were therefore calculated by combining estimates derived from the primary juvenile period, average fire survivorship rates (Barker 2017, Barker 2019a; BMCS 2014, BMCS 2018) and predicted seedling survivorship rates (Ooi 2019) with recent survey data.

5. The extent of occurrence (EOO) was calculated at 2,035 km^2 and is based on a minimum convex polygon enclosing all mapped occurrences of the species, the method of assessment recommended by IUCN (2022). The area of occupancy (AOO) is estimated to be 88 km^2 and was calculated using 2 x 2 km grid cells, the scale recommended by IUCN (2022). Both EOO and AOO were calculated using ArcGIS (Esri 2015), enclosing all confirmed survey records, and cleaned spatial datasets. EOO and AOO were calculated based on occurrence records drawn from BioNet, Atlas of Living Australia, herbarium specimen records, the Global Biodiversity Information Facility, Campbelltown City Council, recent monitoring reports, and recent survey data (BMCS 2014; Barker 2017; BMCS 2018; Barker 2019a, Barker 2019b, Barker 2020, Barker 2021; GBIF 2021; RBGDT 2021; ANHSIR 2023; BAM-C 2023; BioNet 2023; K. Wilkins *in litt.* August 2023; M. Misdale pers. comm. June 2022; M. Saunders pers. obs. August 2023).

6. *Leucopogon fletcheri* subsp. *fletcheri* typically occurs in dry eucalypt woodland or shrubland (NSW Scientific Committee 1999; OEH 2023) on skeletal to moderately deep sandstone soils with minor shale and laminite influences. *Leucopogon fletcheri* subsp. *fletcheri* occurs on ridges, gentle to steep rocky slopes, rock outcrops and cliff edges, and valley floors (M. Saunders pers. obs. August 2023). *Leucopogon fletcheri* subsp. *fletcheri* occurs at elevations ranging from 50–380 m above sea level and appears to prefer cooler, wetter areas, with average annual rainfall of 1,050–1,150 mm and average temperatures of 11–24°C (BMCS 2014, BMCS 2018).

7. *Leucopogon fletcheri* subsp. *fletcheri* is an obligate seeding species, generally killed outright by fire and not known to reproduce vegetatively (BMCS 2014, BMCS 2018), although partially burnt plants may occasionally survive (Barker 2019a). While the taxon appears to flower and produce seed regularly and prolifically, drought has been observed to cause the mass abortion of flowers (BMCS 2014, BMCS 2018). Previous survey data indicate a strong preference for track edges and disturbed sites (BMCS 2018); however, surveys along Springwood Ridge Trail indicate that although plants are abundant along track edges, higher densities can be present in remnant vegetation distant from track edges (M. Saunders pers. obs.

August 2023). While *L. fletcheri* subsp. *fletcheri* may respond positively to fire through seedling recruitment from a persistent soil seedbank, fire is not required for recruitment (BMCS 2018). This is consistent with the idea that *Leucopogon* species are gap recruiters rather than specific post-fire recruiters (Ooi *et al.* 2006a). In other *Leucopogon* species, primary dormancy has been shown to be unaffected by fire cues, although once primary dormancy has been broken, smoke can enhance germination (Ooi *et al*. 2006b). Seedling emergence may also be delayed by almost 12 months by winter fires, resulting in higher mortality and slower growth compared with post-summer fire cohorts (Ooi 2010).

8. *Leucopogon fletcheri* subsp. *fletcheri* flowers from August to October (PlantNet 2023b) and fruit is likely to ripen from November to December (Ooi *et al*. 2006b). *Leucopogon* species have relatively unspecialised flowers which are insect pollinated (Keighery 1996). A diverse range of moth, butterfly, bee, and fly species have been observed visiting *L. fletcheri* subsp. *fletcheri* flowers (BMCS 2014, BMCS 2018), including frequent visitation by the European honeybee (*Apis mellifera*) (Fig. 4; M. Saunders pers. obs. August 2023). Fertilised flowers result in the development of a drupe (OEH 2023), typically containing a single seed per fruit (Maiden and Betche 1897).

9. *Leucopogon fletcheri* subsp. *fletcheri* is threatened by the clearing, fragmentation, and degradation of habitat, resulting from urban development, unrestricted public access, recreational activities, adverse fire regimes, particularly high frequency fire but also high severity fires, and out of season fires. Drought may be a threat to the taxon, although evidence for this is limited. 'High frequency fire resulting in the disruption of life cycle processes in plants and animals and loss of vegetation structure and composition', 'Clearing of native vegetation', and 'Anthropogenic Climate Change' are listed as a Key Threatening Processes under the *Biodiversity Conservation Act 2016*.

10. *Leucopogon fletcheri* subsp. *fletcheri* occurs at eight threat-defined locations as per the IUCN definition (IUCN 2022). Each of the seven subpopulations is considered to occur in an individual threat-defined location, except for the Lower Blue Mountains subpopulation, which occurs in two threat-defined locations. The most serious plausible threats resulting in the lowest number of locations for the taxon are adverse fire regimes, particularly high frequency fire, more intense or severe fire, and changes in fire season, and the clearing, fragmentation, and degradation of habitat. Historical wildfire extent has been used as the primary determinant of locations. Subpopulations located in relatively small areas of contiguous fire-prone bushland lacking fire history have been assigned a location based on the plausible threat of fire affecting the entire area. One subpopulation, located in a highly modified landscape, is more threatened by clearing, fragmentation, and degradation of habitat, and has therefore been assessed under this threat.

11. As a fire-sensitive obligate seeder killed outright by fire, adverse fire regimes are considered a serious plausible threat operating on *Leucopogon fletcheri* subsp. *fletcheri*, particularly high frequency fire, more intense or severe fire, and changes in fire season. Six of the seven subpopulations are considered primarily threatened by fire: St Albans; Blaxlands Ridge; Glenbrook; Lower Blue Mountains; Maroota Ridge; and Kentlyn. Climate change drives interval squeeze effects, in part by slowing accumulation of seed banks (the basis for post-fire regeneration in obligate

seeders) while also reducing the interval between successive fires (Enright *et al.* 2015). The taxon is fire-sensitive, killed outright by fire and with stand replacement reliant upon recruitment from the stored soil seedbank (BMCS 2018; Barker 2019a). Fire frequencies sufficient to kill recruits prior to replenishment of the seed bank threaten obligate seeders such as *L. fletcheri* subsp. *fletcheri* with ongoing decline and local extinction (Bowman *et al.* 2014; von Takach Dukai *et al.* 2018; McColl-Gausden *et al*. 2022). With the Sydney Basin projected to become hotter, have more hot days over 35°C, have more dangerous fire weather days, and have a longer fire season by 2079 (BOM and CSIRO 2022; AdaptNSW 2023), it is plausible that these changes will lead to slower growth rates, reduced seed production, more frequent, intense, and severe fires, and changes in fire season, which will in turn adversely affect the *L. fletcheri* subsp. *fletcheri* population in the future.

12. There is evidence that clearing, fragmentation, and degradation of habitat are contributing to ongoing decline of *Leucopogon fletcheri* subsp. *fletcheri*, and it is expected this will continue due to the large proportion of the population occurring on non-reserved lands. Several sites have experienced adverse effects from habitat clearing and fragmentation in the recent past (Anne Clements and Associates 2013; BMCS 2014; Peak Land Management 2016; Barker 2020; Monahan 2021; B. Heterick *in litt*. August 2023) and there is evidence of this continuing to occur (M. Saunders pers. obs. August 2023). Habitat clearing which occurs for urban development or illegal tracks and trails is inferred to result in a decline in the number of mature individuals through a reduction in available habitat extent.
13. It is estimated and inferred that continuing decline in the area, extent and quality of habitat, and number of mature individuals of *Leucopogon fletcheri* subsp. *fletcheri* is occurring due to the combined effects of clearing, fragmentation, and degradation of habitat, and adverse fire regimes, particularly high frequency fire, more severe fire, and changes in fire season.
14. *Leucopogon fletcheri* Maiden & Betche subsp. *fletcheri* is not eligible to be listed as an Endangered or Critically endangered species.
15. *Leucopogon fletcheri* Maiden & Betche subsp. *fletcheri* is eligible to be listed as a Vulnerable species as, in the opinion of the NSW Threatened Species Scientific Committee, it is facing a high risk of extinction in Australia in the medium-term future as determined in accordance with the following criteria as prescribed by the *Biodiversity Conservation Regulation 2017*:

Assessment against *Biodiversity Conservation Regulation 2017* criteria

The Clauses used for assessment are listed below for reference.

Overall Assessment Outcome: Vulnerable under Clause 4.3(c)(d)(e i,iii)

Clause 4.2 – Reduction in population size of species
(Equivalent to IUCN criterion A)
Assessment Outcome: Data deficient

(1) - The species has undergone or is likely to undergo within a time frame appropriate to the life cycle and habitat characteristics of the taxon:			
	(a)	for critically endangered species	a very large reduction in population size, or
	(b)	for endangered species	a large reduction in population size, or
	(c)	for vulnerable species	a moderate reduction in population size.
(2) - The determination of that criteria is to be based on any of the following:			
	(a)	direct observation,	
	(b)	an index of abundance appropriate to the taxon,	
	(c)	a decline in the geographic distribution or habitat quality,	
	(d)	the actual or potential levels of exploitation of the species,	
	(e)	the effects of introduced taxa, hybridisation, pathogens, pollutants, competitors or parasites.	

Clause 4.3 - Restricted geographic distribution of species and other conditions (Equivalent to IUCN criterion B)

Assessment Outcome: Vulnerable under Clause 4.3(c)(d)(e i,iii)

The geographic distribution of the species is:			
	(a)	for critically endangered species	very highly restricted, or
	(b)	for endangered species	highly restricted, or
	(c)	for vulnerable species	moderately restricted,
and at least 2 of the following 3 conditions apply:			
	(d)	the population or habitat of the species is severely fragmented or nearly all the mature individuals of the species occur within a small number of locations,	
	(e)	there is a projected or continuing decline in any of the following:	
		(i)	an index of abundance appropriate to the taxon,
		(ii)	the geographic distribution of the species,
		(iii)	habitat area, extent or quality,
		(iv)	the number of locations in which the species occurs or of populations of the species,
	(f)	extreme fluctuations occur in any of the following:	
		(i)	an index of abundance appropriate to the taxon,
		(ii)	the geographic distribution of the species,
		(iii)	the number of locations in which the species occur or of populations of the species.

Clause 4.4 - Low numbers of mature individuals of species and other conditions
(Equivalent to IUCN criterion C)
Assessment Outcome: Not met

The estimated total number of mature individuals of the species is:						
	(a)	for critically endangered species			very low, or	
	(b)	for endangered species			low, or	
	(c)	for vulnerable species			moderately low,	
and either of the following 2 conditions apply:						
	(d)	a continuing decline in the number of mature individuals that is (according to an index of abundance appropriate to the species):				
		(i)	for critically endangered species		very large, or	
		(ii)	for endangered species		large, or	
		(iii)	for vulnerable species		moderate,	
	(e)	both of the following apply:				
		(i)	a continuing decline in the number of mature individuals (according to an index of abundance appropriate to the species), and			
		(ii)	at least one of the following applies:			
			(A)	the number of individuals in each population of the species is:		
				(I)	for critically endangered species	extremely low, or
				(II)	for endangered species	very low, or
				(III)	for vulnerable species	low,
			(B)	all or nearly all mature individuals of the species occur within one population,		
			(C)	extreme fluctuations occur in an index of abundance appropriate to the species.		

Clause 4.5 - Low total numbers of mature individuals of species (Equivalent to IUCN criterion D)
Assessment Outcome: Not met

The total number of mature individuals of the species is:			
	(a)	for critically endangered species	extremely low, or
	(b)	for endangered species	very low, or
	(c)	for vulnerable species	low.

Clause 4.6 - Quantitative analysis of extinction probability (Equivalent to IUCN criterion E)
Assessment Outcome: Data deficient

The probability of extinction of the species is estimated to be:			
	(a)	for critically endangered species	extremely high, or

	(b)	for endangered species	very high, or
	(c)	for vulnerable species	high.

Clause 4.7 - Very highly restricted geographic distribution of species– vulnerable species
(Equivalent to IUCN criterion D2)
Assessment Outcome: Not met

For vulnerable species,	the geographic distribution of the species or the number of locations of the species is very highly restricted such that the species is prone to the effects of human activities or stochastic events within a very short time period.

Professor Caroline Gross
Chairperson
NSW Threatened Species Scientific Committee

Supporting Documentation:

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